CALIFORNIA DIVISION OF MINES AND GEOLOGY

Fault Evaluation Report FER-72

September 6, 1978

1. Name of fault: Elsinore fault zone, segment from Lake Elsinore to Prado Dam, Riverside County.

2. Location of fault: This segment of the Elsinore fault zone lies within Riverside County, forms the northeastern boundary of the Santa Ana Mountains, extends from just southeast of Lake Elsinore to the vicinity of Prado Dam, and lies within the Elsinore, Alberhill, Lake Mathews, and Corona South Quadrangles (figure 1).

3. Reason for evaluation: This fault is located within the 1978 study area of the 10-year program for fault evaluation.

4. List of references:

Davis, W.M., 1927, The rifts of southern California: American Journal of Science, v. 13, p. 57-72.

Engel, Rene, 1959, Geology of the Lake Elsinore quadrangle, California: California Division of Mines Bulletin 146, 154 p.

Fairbanks, H.W., 1893, Geology of San Diego County; also of portions of Orange and San Bernardino Counties: California State Mining Bureau, Report 11, p. 76-120.

(Riverside County was included with San Diego County when this report was written.)

Gaede, V.F., 1969, Prado-Corona oil field: California oil fields, Summary of Operations, v. 55, no. 1, p. 23-29.

Ghaeni, M.R., 1967, Gravity survey of the Elsinore-Murrieta Valley, California. Unpublished M.S. thesis, University of California, Riverside, California, 45 p.

(Gravity survey of the Lake Elsinore area. His work shows the boundaries of the Elsinore trough. They are similar to what would be expected on the basis of surface topography.)

Gray, C.H., Jr., 1961, Geology of the Corona South quadrangle and the Santa Ana Narrows area, Riverside, Orange, and San Bernardino Counties, California: California Division of Mines Bulletin 178, 120 p. Map scale 1:24,000.

Jennings, C.W., 1975, Fault Map of California with locations of volcanoes, thermal springs and thermal wells: California Division of Mines and Geology, California Geologic Data Map Series, Map no. 1. Scale 1:750,000.

Lamar, D.L., 1959, Geology of the Corona area, Orange, Riverside, and San Bernardino Counties, California. Unpublished masters thesis, University of California, Los Angeles, 95 p. Map scale 1:12,000.

Langenkamp, Davis, and Combs, Jim, 1974, Microearthquake study of the Elsinore fault zone, southern California: Seismological Society of America Bulletin, v. 64, no. 1, p. 187-203.

Lawson, A.C., and others, 1908, The California earthquake of April 18, 1906, Report of the State Earthquake Investigation Committee: Carnegie Institution of Washington Publication 87, v. 1, part 1 and 2, 451 p.

(The authors included H.W. Fairbanks, who presumably was responsible for data on the Elsinore fault; see also Fairbanks, 1893.)

Lohr, Lewis S. and Associates, 1978, Fault hazard investigation for parcel map no. 11,055, a division of a portion of the SW¼ of section 27, T 5 S, R 5 W, SBB&M, lying within Riverside County, California. Unpublished consulting report for Homestead Realty, Lake Elsinore, California, 7 p. (A-P no. C-308, Riverside County report no. GR-122).

Lohr, L.S., 1978a, Fault hazard investigation for tract no. 10,828, Riverside County, California. Unpublished consulting report for William L. Stewart, Riverside, California, 6 p. (A-P no. C-295, Riverside County report no. GR-118.)

Lohr, L.S., 1978b, Fault hazard investigation for tract no. 12406, Riverside County, California. Unpublished consultants report for Richard Shoemaker, Lake Elsinore, California, 6 p. (A-P no. C-325, Riverside County report no. GR-143.

Pioneer Consultants, 1976, Geologic investigation, tract no. 7240 (Riverside County, California). Unpublished consultants report for Temescal Sales Company, Corona, California, 9 p. (A-P no. C-88, Riverside County, no. GR-45).

Rand, L.E., 1977, Fault hazard investigation for tentative parcel map no. 9070, the southeasterly 490' of lot 6, block "K" of Elsinore, in the unincorporated County of Riverside County (sic), California. Unpublished consultants report for Mr. George Nyiri, 7 p. (A-P no. C-228, Riverside County report GR-79.)

Real, C.R., Parke, D.L., and Toppozada, T.R., 1977, Magnetic tape catalog of California earthquakes, 1900-1974: California Division of Mines and Geology.

Scullin, C.M., 1977a, Engineering geologic-seismic evaluation and feasibility of development, lots 1-15, tract 7219, Rancho Corona Drive, Riverside County, California. Unpublished consultants report for AG&H Enterprises, Inc., Corona, California, 28 p. (A-P no. C-202, Riverside County report no. 72).

Schlin, C.M., 1977b, Engineering geological-seismic evaluation and feasibility of development, lots 1-20, tract 8830, Green River Road and Serfus Club Drive, Lorona area, Riverside County, California. Unpublished consultants report for La Sierra Stock Ranch Development Corporation, Rancho Santa Fe, California, 33 p. (A-P no. C-280, Riverside County no. GR-105.)

Stickel and Associates, 1977a, Report of engineering geological seismicity study for a proposed school site, Grand Ave., Lakeland Village, California. Unpublished consultants report for Elsinore Public Schools, Lake Elsinore, California, 9 p. (A-P no. C-266, Riverside County report no. GR-102.)

Stickel,and Associates, 1977b, Report of engineering geological seismicity study for tentative tract 9837, Rice Road, Elsinore, California. Unpublished report for Crosby Financial, San Juan Capistrano, California, 9 p. (A-P no. C-284, Riverside County report no. GR-107).

Weber, F.H., 1977, Seismic hazards related to geologic factors, Elsinore and Chino fault zones, northwestern Riverside County, California: California Division of Mines and Geology Open File Report 77-4LA, 96 p. Map scale 1:24,000.

Wood, H.O., 1916, California earthquakes: Seismological Society of America Bulletin, v. 6, no. 2, p. 55-180.

Smith, D.P., 1978, Fault Evaluation Report FER-38, Chino fault and the northernmost part of the Elsinore fault. Unpublished report, California Division of Mines and Geology, San Francisco.

5. Summary of available data:

Knowledge of the existence of the fault zone dates back at least to Fairbanks (1893), who described features of large-scale faulting in the Temecula-Elsinore area. The fault was first shown on a published map and mentioned by the name "Elsinore" by Lawson and others (1908, Map no. 1, and p. 19). Wood (1916) tabulated the historical earthquakes of California, and suggests that a number of the earthquakes may have occurred along the Elsinore fault. Davis (1927), discusses the characteristics of the major "rifts" of southern California, and, in several cases, refers to localities along the northern Elsinore fault as examples of various types of features. Engel (1959), mapped the Lake Elsinore 15-minute quadrangle, and discusses the characteristics of the various fault traces of the Elsinore fault zone. Gray (1961) did likewise for the Corona South quadrangle. Langenkamp and Combs (1974), conducted a microseismic study of the Elsinore fault in Riverside and San Diego Counties, and found a general increase in microseismic activity from northwest to southeast along the entire length of the fault. Weber (1977) conducted a detailed study of that part of the Elsinore fault zone that lies at, and to the northwest of, Lake Elsinore. Since 1976 there have been at least eight private geologic investigations involving trenching along the segment of the Elsinore fault zone that is under consideration in this FER. The Chino fault and the northwesternmost part of the Elsinore fault zone were investigated by Smith (1977). There is some overlap in the areas considered in that FER and this FER. Fault segments extending into the Black Star Canyon quadrangle are shown and discussed in the earlier FER.

The segment of the Elsinore fault zone herein considered forms the structural boundary between the Santa Ana Mountains, which lie to the southwest, and the Perris block which lies to the northeast. The total length of this segment is about 44 km. It extends from near Prado Dam southeastward to a point several kilometers southeast of Lake Elsinore (figure 4). The fault zone consists of a series of subparallel traces that lie within a zone that ranges from 1 km to 4 km wide. The geomorphic features along these traces indicate that most of the late Quaternary offset northwest of Lake Elsinore has occurred along one through-going fault trace. This through-going fault includes segments of such locally-named strands as the Chino fault, the Main Street fault, and the Glen Ivy North fault. The other branches, based on surface expression, are either secondary faults or represent former major fault traces that became relatively inactive during late Quaternary time. To the southeast of Lake Elsinore, the focus of offset during late Quaternary time is along the Wildomar fault. This trace is parallel to the Glen Ivy North fault, but lies about two km to the southwest (figure 4). This is a right-stepping offset of the main trace of the Elsinore fault. Combined with right-lateral movement along the fault, this type of geometry would be expected to produce a graben at the point where the fault makes the right step. The existence of Lake Elsinore indicates that this has in fact happened.

Most of the longer branches of the Elsinore fault trend N 40° W to N 50° W, and have dips that range from vertical to shallowly southwestward. The various fault traces have been delineated on the basis of actual exposures of the fault, juxtaposition of unlike lithologies, scarps, deflected drainages, and closed depressions.

Weber (1977, p. 4) gives the following general discussion of recency of faulting along this segment of the Elsinore fault zone:

> The most active segments1/ of the Elsinore zone appear to be the Main Street, Glen Ivy South, and Wildomar segments,1/ and the Glen Ivy North segment (from its northwest end to the southeast end of Elsinore Lake). The Main Street segment is a moderately southwest-dipping fault, which is crossed by deflected drainages. The Glen Ivy North segment is at least partly a high angle fault;

1/ Weber's use of fault "segment" is equivalent to the use of "strand" in this report.

> its youthfulness is expressed by low, fresh-appearing scarps in relatively young alluvium, and offset and deflected drainages. The Wildomar zone bounds Rome Hill and additional linearily arranged low hills which have been faulted upward relatively recently along the zone; strong topographic linearity, youthful-appearing scarps, and closed depressions along faults of the segment also suggest overall youthfulness of faulting. Certain geomorphic elements of faulting along the Chino fault zone, and the remaining segments of the Elsinore zone also suggest relative recency of activity.

Gray (1961, p. 49) gives the following general discussion of recency of faulting along the Chino fault and the northwesternmost part of the Elsinore fault (mainly that part which lies within the Corona South quadrangle):

> The most compelling evidence in the mapped area suggests that the initiation of predominantly vertical movement along the Elsinore and Chino faults commenced prior to late Pleistocene time. That it probably occurred mostly in late Pliocene and early Pleistocene time is strongly suggested by the marked unconformity between Quaternary terrace deposits and highly deformed Pliocene (?) strata. However, geomorphic and topographic features, including aligned scarplets and trenches, as well as anomalous drainage lines, scarps, and benches, indicate the movement has continued into Recent time. That the movement has been discontinuous is shown by the extensive occurrence of terrace surfaces at different elevations.

In the discussion that follows, the various named traces of the Elsinore fault zone will be described individually. The names used by Weber (1977, plates 2A and 2B) will be used here (they are shown on figure 4 of this FER).

Chino fault southeast of the Santa Ana River:

To the southeast of the Santa Ana River, the Chino fault trends in about a S 40^{o} E direction and converges with the complex Elsinore fault zone somewhere between Main Street Canyon and Bedford Canyon (figure 4). Only three people have prepared large-scale maps of this part of the Chino fault (Lamar, 1959; Gray, 1961; and Weber, 1977), but there is much disparity among them in their location of the fault and the evidence they use. Lamar (1959, p. 70) says, "it has been assumed that the fault is located at a rather indistinct topographic break marking the approximate northeast edge of stream deposits." He is not clear about the location and extent of this topographic feature.

Gray (1961, p. 47) says:

> Southeast of the Puente-Chino Hills the fault is largely or wholly hidden beneath alluvium, but its projected course appears to gradually converge upon and to perhaps eventually join the Elsinore fault. Sharp differences in groundwater levels in water wells on La Sierra Stock Ranch near State Highway 18, as well as topographic features (chiefly anomalous, narrow trenches) indicate that the fault may cross the Santa Ana River and extend southeast of Highway 18 along the first major wash cut in the older alluvium east of Wardlow Wash. Farther southeast, along the margin of the Santa Ana Mountains, the chief evidence for the Chino fault is topographic. A well-defined scarp at the contact between terrace deposits and older alluvium may be the surface expression of the Chino fault. Its trace also may coincide with anomalous scarplets and benches, especially between Mabey and Main Street Canyons, and with offset drainage lines in the streams between Main Street and Joseph Canyons. The southeastward projection of the trace of the Chino fault from its easternmost exposure in the Puente-Chino Hills suggests that the Chino fault joins one of the faults parallel to the Elsinore fault west of Bedford Canyon and thence joins the Elsinore fault between Bedford and Brown Canyons.

Weber (1977, p. 42) says:

> Southeast of the Santa Ana River, a prominent northeast-facing, modified scarp occurs between Paseo Grande and Avenida del Vista (photo 13; LQ-7, plate 2a); and an apparent modified scarp lies at the foot of Lincoln Avenue, with older alluvium displaced upward to the southwest (VQ-12, plate 2a). From Lincoln Avenue northwestward the projection extends along Wardlow Wash, from where older alluvial fan deposits apparently are displaced upward to the southwest (Qofu) relatively to the northeast (Qof). Between the Riverside Freeway and the Santa Ana River, however, similar displacement of older floodplain deposits (Qov) is shown only very tentatively; no clear trace of the fault exists here, nor across the Santa Ana River bed, as interpreted from the pre-Prado Dam aerial photographs.
>
> The trace of the Chino fault between the Santa Ana River and the intersection of Chase Drive and Lincoln Avenue, southwest of Corona, is mapped slightly differently for this report than by Gray (1961, plates 1 and 3). Gray shows the fault to bow to the northeast about one-half mile (0.3 km), partly on the basis of differences in elevation of water in wells and partly on the belief that the fault trace extends along the bottom of a linear canyon south of the freeway. Perhaps the position of the fault trace as mapped by Gray (1961) through this area represents a second, parallel fault, equivalent to the Sardco fault of Gaede (1969) and the Division of Oil and Gas (1974).

Scullin (1977a) conducted exploratory trenching across the location of Weber's (1977) inferred fault along Wardlow Wash (locality C-202 on figure 4).

Scullin recognized three lithological units in this area: topsoil, recent alluvium, and older alluvium. Most of his trenches penetrated into older alluvium (according to his trench logs), but about 25 percent penetrated only into younger alluvium. The trenches, ranging from five feet nine feet in depth, yielded no evidence of faulting.

Later that year, Scullin (1977b) conducted exploratory trenching at another site along Wardlow Wash, immediately to the northwest of the above site (locality C-280 on figure 4). Again, he did not find any evidence of faulting.

Weber (1977, plate 2a) indicates Holocene offset along the Chino fault in the vicinity of Mangular Avenue (his location H10). Appendix A of this FER is a reproduction of Weber's (1977) table 1; it provides brief descriptions of the various numbered locations shown on Weber's map (plates 2A and 2B, also shown on figure 4 of this FER). His Holocene interpretation is based on the observation of a vegetation lineament across Holocene alluvium.

Fresno fault strand

This fault strand was previously discussed in FER-38.

Tin Mine fault

This fault extends about 4 km southeasterly from the southern end of Fresno Canyon to Tin Mine Canyon (only partly shown on Fig. 4). Weber (1977, p. 17) describes the fault as "apparently mostly vertical at the surface." Offset older alluvium and deflected drainages and other geomorphic features along the fault suggest late Quaternary activity (Weber, 1977, plate 2a). He does not indicate Holocene activity along the Tin Mine segment, even where it crosses Holocene stream deposits in Mabey and Tin Mine canyons.

Eagle fault

The Eagle fault extends from near Wardlow Canyon southeast to Brown Canyon, a distance of about 14 km. The fault dips 15° to 35° southwestward. The rock units cut by the fault range in age from late Jurassic to Paleocene. Several drainages show apparent right deflections at this fault, and Weber (1977, p. 21) says, "... relatively recent landslide deposits apparently are faulted (VQ-31, plate 2a)." He does not indicate Holocene activity along the Eagle fault segment on his annotated map (plate 2A).

Main Street fault

This fault segment extends from Mabey Canyon to Joseph Canyon, a distance of about 6.5 km. The fault is characterized by an alignment of discontinuous, steep, modified, northeast-facing scarps that are typically about 60 m high. Regarding the attitude and sense of displacement along the segment, Weber (1977, p. 24) says:

> Although faults of the segment are not clearly exposed along the front of the hills, steep, overturned bedding of Paleocene rocks exposed in the hills, along with pertinent geomorphic features, suggest that the fault dips moderately to possibly steeply southwestward. Reverse displacement seems to have been the principal component of faulting along the segment, but a lateral component probably also exists.

Weber (1977, p. 22) observed older alluvium to be offset by the fault. His figure 3 (reproduced as figure 3 of this FER) shows, in cross section, the topographic and geometric relationships among the Chino, Main Street, and Eagle faults. Weber (1977, plate 2a and p. 87) indicates offset of Holocene sediments along the Main Street fault near the west end of Upper Drive (his location H-13b).

Glen Ivy North fault

This fault is about 30 km long. It extends southeastward from Brown Canyon, near the northwestern end of Temescal Valley, to about 8 km southeast of Elsinore (Fig. 4). The change in name, at the northwestern end, from "Glen Ivy North" fault to "Eagle" fault is somewhat arbitrary; there is no break in the relatively linear trace of the fault. However, the sense of apparent vertical offset changes at about that point. To the northwest (Eagle fault) the southwestern side of the fault is the apparently upthrown side; to the southeast (Glen Ivy North fault segment) the northeastern side is apparently upthrown.

Engel (1959) observed abundant evidence for Pleistocene offset along this fault strand, but does not present specific discussions of Holocene offset. Weber (1977) believes that most of this strand has been active during Holocene time, he cites evidence to support that interpretation, and his annotated map (Pl. 2a and 2b) shows numerous localities along the northwesternmost two-thirds of the strand where he observed features indicative of Holocene offset. Three private consulting studies have been conducted along the Glen Ivy North fault; all three involved trenching. Only one of these investigations, near the northwestern end of the strand, was able to locate the fault in trenches (Pioneer, 1976). This investigation also indicated that the fault has been active during Holocene time and perhaps during historical time.

Weber (1977, p. 28) says that the Glen Ivy North segment is a "very high angle fault." Pioneer Consultants (1976, p. 4) describe one exposure of the fault near the northwestern end of Temescal Valley (locality C-88 on figure 4), where they observe the fault to be dipping steeply to the southwest. They observe sandstone of the Silverado Formation (Paleocene age) on the northeast faulted against fanglomerate (Pleistocene(?) age) on the southwest in their trench TR-4, and just north of there. However, Weber (1977, p. 29) observed a different relationship at what appears to be the same location (Weber's location H-46, plate 2B). He observed the Silverado Formation on the northeastern side faulted against older "igneous-metamorphic rocks" to the southwest.

In their trench no. 4, Pioneer Consultants (1976, p. 4) observed the Glen Ivy North fault trace to be a zone of gouge and disruption, within older fanglomerate, 50 to 60 feet wide. They observed slickensides to extend to within less than two feet from the surface. They also cite evidence for ongoing creep along the fault (p. 4):

> 8. Through personal discussions with long-time employees of the Temescal Water Company, it was determined that a city water line which crosses the suspected fault trace in the vicinity of Hunt Road has required repair annually over the past 20 years. This water line is currently leaking and the continuous disruption of this main is considered to be a reflection of the continual creep along the suspected fault.

> 10. Along Lawson Road approximately 1200 feet west of its intersection with Temescal Canyon Road there are exposed in the asphalt surface parallel cracks which bear essentially N 40° W or in line with the trend of Fault no. 1. There are approximately nine of these cracks and it is presumed that these are due to continual creep along the fault trace rather than any differential settlement which may have occurred in the road base materials.

Pioneer Consultants (1976, p. 5) also mention "distinct vegetation differences" and "topographic depressions" which they believe are associated with the fault. These features occur a few hundred meters to the southeast of the road cracks mentioned above. The above localities are annotated on figure 4 of this FER. Weber (1977, p. 90) observed the road cracks, but believes they were probably caused by settling of fill.

Farther to the southeast, Weber (1977, p. 31) observed vertical fractures in older alluvium along the trace of the Glen Ivy North fault. He includes a photo of this exposure (his photo 7, p. 31) and, in the caption, says "Some fractures apparently cut through soil to ground surface." The exposure is a stream cut along Rice Canyon Creek, and involves the more northerly of the two traces at his locality H-65. About one kilometer farther to the southeast, Weber (1977, p. 29) observed a southwest-facing scarp in "relatively young alluvium" near the point where the fault crosses Graham Road (his locality H-68 along the Glen Ivy North fault).

Lewis S. Lohr and Associates (1978) conducted a "fault hazard investigation" in the area between Weber's localities H-65 and H-68 (locality C-308 on figure 4). They dug two trenches and observed no evidence of faulting. Lohr states:

> It is also my opinion that neither of the "Glen Ivy North" fault branches through the southwesterly corner of the property exist. These faults were mapped by Weber (1977) and are shown on figure 4. The reason for my stated opinion includes the fact that the apparent scarp feature noted by Weber was trenched and no evidence of fault displacement was seen. Also, no geomorphic expression, changes in vegetation, lithologic differences, or color changes were found on or adjacent to this property, which would indicate the presence of these two faults.

However, careful examination of Lohr's maps and Weber's map (1977, pl. 2B) indicates that Lohr mis-plotted the location of the fault traces as mapped, by Weber. Lohr's more northerly trench does not lie across Weber's mapped trace of the fault. Lohr's more southerly trench, however, did cross the southwest-facing scarp mentioned by Weber. Lohr found no evidence for faulting there.

Farther to the southeast along the Glen Ivy North fault, at a point about 2 km north-northwest of Lake Elsinore, Weber (1977, p. 93) cites additional evidence for Holocene faulting at his locality H-74.

He says, "Subtle geomorphic features suggest possible pattern of faulting shown and displacement of younger sediments." Stickel and Associates (1977b) conducted a geological investigation of a site that includes Weber's H-74 locality (locality C-284 on figure 4). They found no evidence for faulting, either at the surface or in trenches 10 to 15 feet deep.

Glen Ivy South fault

This fault lies along the southwestern side of Temescal Valley. The fault strands dip to the southwest with granitic basement rock on the southwestern side locally reverse faulted over older alluvium on the northeastern side. Weber (1977, p. 34) says, " ... relatively recent displacement on these faults is suggested by deflected drainages, modified fault scarps, faceted spurs, hot spring activity (Glen Ivy Hot Springs), and apparently displaced older and slightly older alluvium ..." He does not state what the sense of offset is at the deflected drainages. On his annotated map he shows two localities (H-47 and H-49) having evidence for Holocene faulting. On his p. 90 he says of locality H-47, "Possible faulting of alluvial fan (Qf) and stream channel (Qsc) deposits suggested by mapping." For H-49, he says "Aerial photograph features suggest youthful faulting; relatively pristine scarps along most southwesterly portion of trace indicated."

North Elsinore fault

This fault was mapped by Engel (1959), but not by Weber (1977). Engel (1959, p. 52) gives the following description of the fault:

> North Elsinore fault. The North Elsinore fault can be traced by means of abrupt dissimilarities encountered along its strike, either in the Tertiary rocks or in the metamorphic rocks. Prospects for coal and clay on the Langstaff Ranch showed beds of clay on the northeast side of the fault and none on the southwest side. In metamorphic rocks, on a ridge northeast of the town of Elsinore, an abrupt change of dip and strike in the slates and quartzites and truncation of dikes closely corresponds to a saddle on this ridge. Moreover, in the eucalyptus grove on the north side of the Atchison, Topeka and Santa Fe railroad tracks, this fault line is still visible in the form of a crevice in the alluvium on the southwest side of a road that traverses the grove. This crevice has been somewhat obliterated by caving and filling, but in 1926 it was traceable for at least an eighth of a mile and formed a trench that in places was more than 10 feet deep and averaged 2 or 3 feet in width. Small and shallow anastomosing cracks oriented subparallel to the major one were then visible, but they have now entirely disappeared. According to residents of the valley, this system of crevices was developed at the time of the San Jacinto earthquake in 1918.

Weber (personal communication, August 1978) was unable to find the features described by Engel; they apparently have been modified to the point where they are no longer recognizable. Weber did, however, ascertain the probable location of the features, and shows it as his locality H-76.

Willard fault

This fault forms the southwestern boundary of the Elsinore trough. Neither Engel (1959) or Weber (1977) mention any actual exposures of this fault; its existence and location are based on gross structural and geomorphic evidence. Both writer's believe the fault to be vertical or steeply dipping. Weber (1977, p. 36) says there are "... some low, probable fault scarps in older to younger alluvium of (sic) along the apparent trace (H?-77, 80, 82; VQ?-85, 89; plate 1a)."

Lohr (1978a and 1978b) conducted fault hazard investigations on two tracts near the eastern end of the Willard fault (localities C-295 and C-325 on figure 4). He states, in both, that he saw no geomorphic evidence for the fault, such as the "youthful geomorphic features" mentioned by Weber (1977). He saw no evidence of faulting in trenches 10 to 12 feet deep.

Stickel and Associates (1977a) conducted a site geologic investigation farther to the southeast along the Willard fault at locality C-266 as shown on figure 4. Their site included both traces of the Willard fault as mapped in that area by Weber (1977). They were unable to find any evidence for faulting on the site, either at the surface or in a 10 to 15 foot deep trench. They did observe (p. 7): "A probable fault trace was observed immediately south of the site which may have offset alluvial fans."

Rand (1977) conducted a geologic site investigation within the Willard fault zone farther to the southeast, at a point about 2 km northwest of the town of Wildomar (locality C-228 on figure 4). At that site, he observed no evidence for faulting; either at the surface or in a trench.

It is apparent from the work cited above that the Willard fault is poorly defined in the map area of this FER.

Wildomar fault

Neither Engel (1959) or Weber (1977) say much about this segment, but their brief descriptions suggest that youthful, probably Holocene, geomorphic features are much more abundant along this segment than any of the others discussed in this FER. Engel's (1959, p. 54) entire description is:

> The Wildomar longitudinal fault zone limits the Elsinore trough on its northeast side and is marked by a prominent alignment of sags, fault-line scarps, and displaced outcrops. These features are exposed on the northeast side of State Highway 71 as far south as Temecula and northwest to Rome Hill. The width of the fault zone is about a quarter of a mile; the average strike is about N 56° W, and the apparent dip is vertical. The upthrown side is on the northeast near Wildomar and on the southwest at Rome Hill, indicating a rotational fault that pivoted at some point between Wildomar and Rome Hill.

The apparent offset relationships described in the last sentence above could also have been caused by right-lateral offset.

Weber (1977, p. 39) also mentions youthful scarps and sag ponds along the Wildomar segment (localities H-81, H-82, VQ-85, and VQ-89), and believes the fault to dip very steeply southwest.

Seismicity

The seismicity of the northern Elsinore fault region, from 1900 to 1974, is shown on figures 2a and 2b. In general, these plots show a moderate number of events along the southwestern side of the fault. They are distributed within a zone as much as 10 km wide that is bounded on the northeast by the Elsinore fault. There is a strong local clustering of epicenters in the area just southwest of Glen Ivy Hot Springs. To the northeast of the fault zone, there has been little seismicity within the first 5 km, but the density of events increases considerably beyond about 10 km from the fault.

Since the field evidence indicates that the Elsinore fault zone dips to the southwest in this area, the epicenters along the southwestern side of the fault may represent activity on that fault. The clustering of events near Glen Ivy Hot Springs is also adjacent to a part of the fault zone for which there is an increase in the density of evidence for recent activity. This area includes Weber's localities H-43, H-46, H-47, and H-49. It also includes the study site of Pioneer Consultants (1976).

Langenkamp and Combs (1974) conducted a microearthquake study along the Elsinore fault zone between Corona and the Mexican border. They found a general increase in microseismicity toward the southeast, but their study detcted no events in the area under consideration in this report.

6. Interpretation of aerial photos

None at this time.

7. Field observations

None at this time.

8. Conclusions

The descriptions and evidence available in the literature are insufficient to allow me to make decisions about the recency of faulting for most of the faults. In some cases even the location of a fault trace is quite uncertain. I can conclude that the Wildomar fault segment southeast of Lake Elsinore probably has been active during Holocene time; likewise for the northwesternmost 3 km of the Glen Ivy North fault segment. The Willard fault may be too poorly defined to zone. For the rest of the faults, it is not clear just how old the observed features are. "Relatively young alluvium" is a term used by Weber which he does not define. Nor is the term "youthful appearing scarps" defined. I do not say this as a criticism of the workers; they had no means of quantifying such evidence at that time, and even today that situation is only slightly improved. Weber has made interpretations as to the age of many of the fault features and alluvial units that he observed. These interpretations are shown as annotations on his map (his plates 2A and 2B, and on figure 4 of this FER). I cannot draw conclusions based on his interpretations until I see the features he observed and see how my interpretations compare with his.

9. Recommendations

I make no recommendations for or against zoning at this time. I recommend a brief aerial photo study of the area, especially since I now have in my possession several good sets of aerial photo coverage of the area dating back to 1930. After that, I recommend a field check of the area. I do not recommend that any new mapping be attempted; only that the features shown on existing maps, especially Weber (1977), be checked. I recommend that, if possible, we should spend some time in the field with Weber.

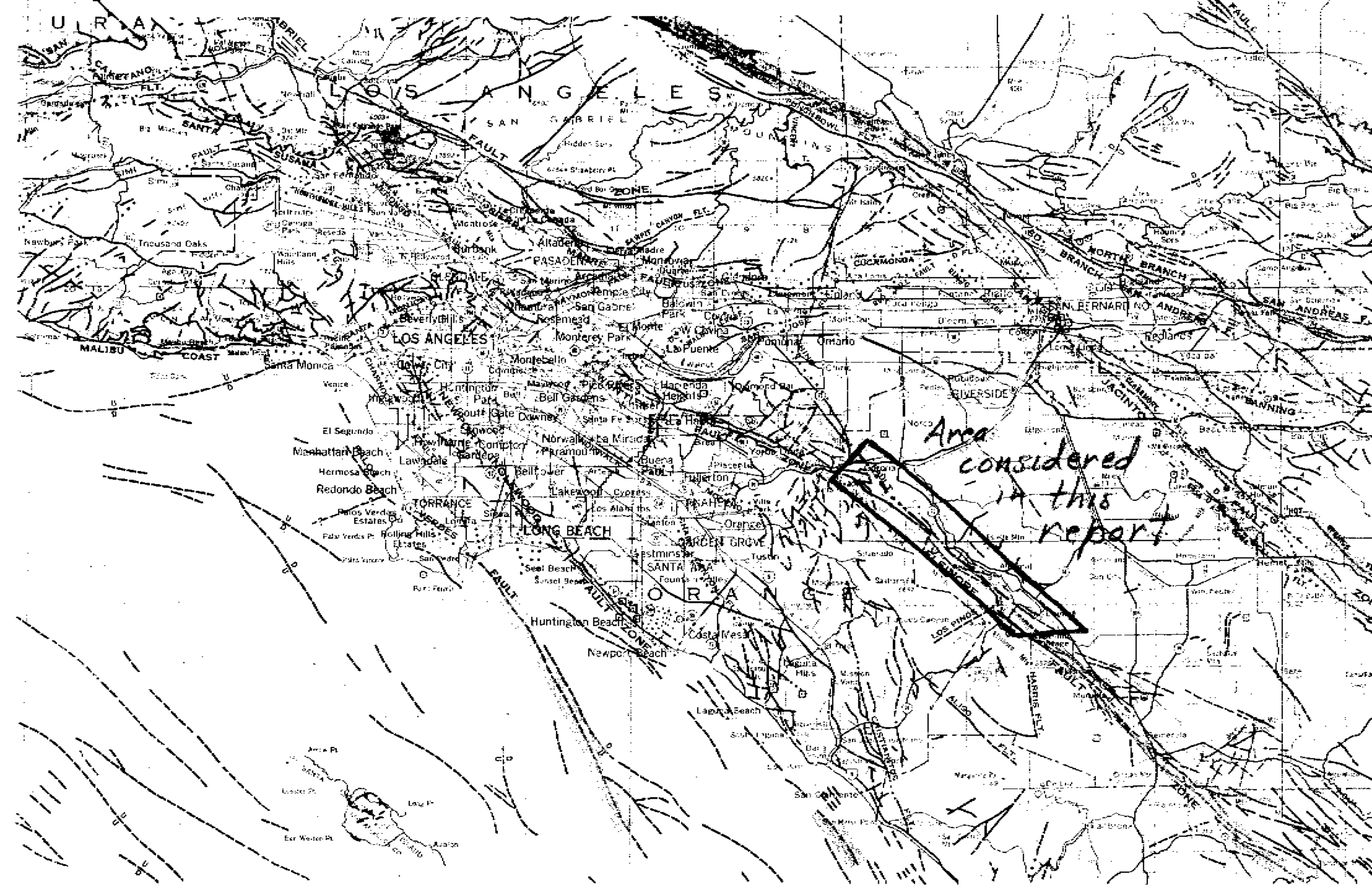
10. Investigating geologist's name and date

Drew P. Smith
DREW P. SMITH
Geologist
September 6, 1978

DPS/mkr

I concur with the recommendations, as most of the fault traces mapped by Weber either are not clearly Holocene or ~~ap~~ are poorly-defined. The process of determining which faults ~~are~~ should be zoned and which should not is exceedingly difficult for the Elsinore fault zone.
EWH
10/14/78

FER 72 Figure 1. Index map showing the location of the segment of the Elsinore fault that is being considered in this report. Map is modified from Jennings (1975).

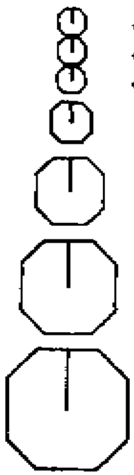


EPICENTERS IN THE L. A. AREA, "A" QUALITY

TRANSVERSE MERCATOR PROJECTION

SCALE = 1/250000

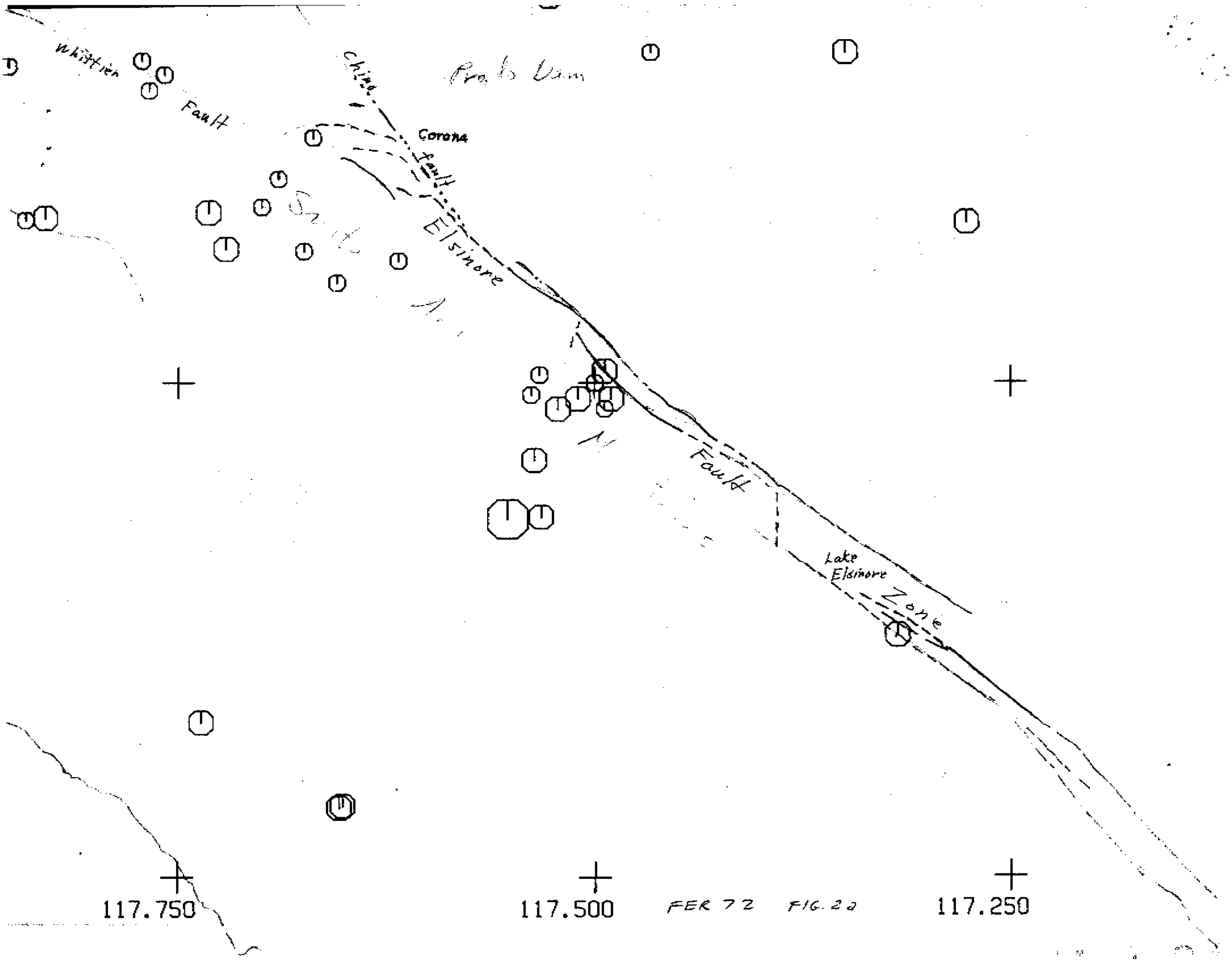
MAGNITUDE



..... 0.0 TO 0.9
..... 1.0 TO 1.9
..... 2.0 TO 2.9
..... 3.0 TO 3.9
..... 4.0 TO 4.9
..... 5.0 TO 5.9
..... 6.0 TO 6.9

FER 72

Figure 2a. Seismicity in the vicinity of the Elsinore fault zone, 1900–1974, northern Riverside County. "A" quality epicenter plots from Real and others (1977) are of ± 2 to 3 km accuracy.



Whittier Fault
Chino
Corona
fault
Elsinore
Fault
Lake Elsinore
Zone
Prado Dam
117.750
117.500
117.250

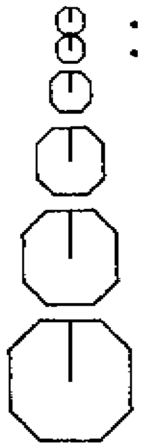
FER 72 FIG. 2a

EPICENTERS IN THE L. A. AREA, "B" QUALITY

TRANSVERSE MERCATOR PROJECTION

SCALE = 1/250000

MAGNITUDE



..... 1.0 TO 1.9

..... 2.0 TO 2.9

..... 3.0 TO 3.9

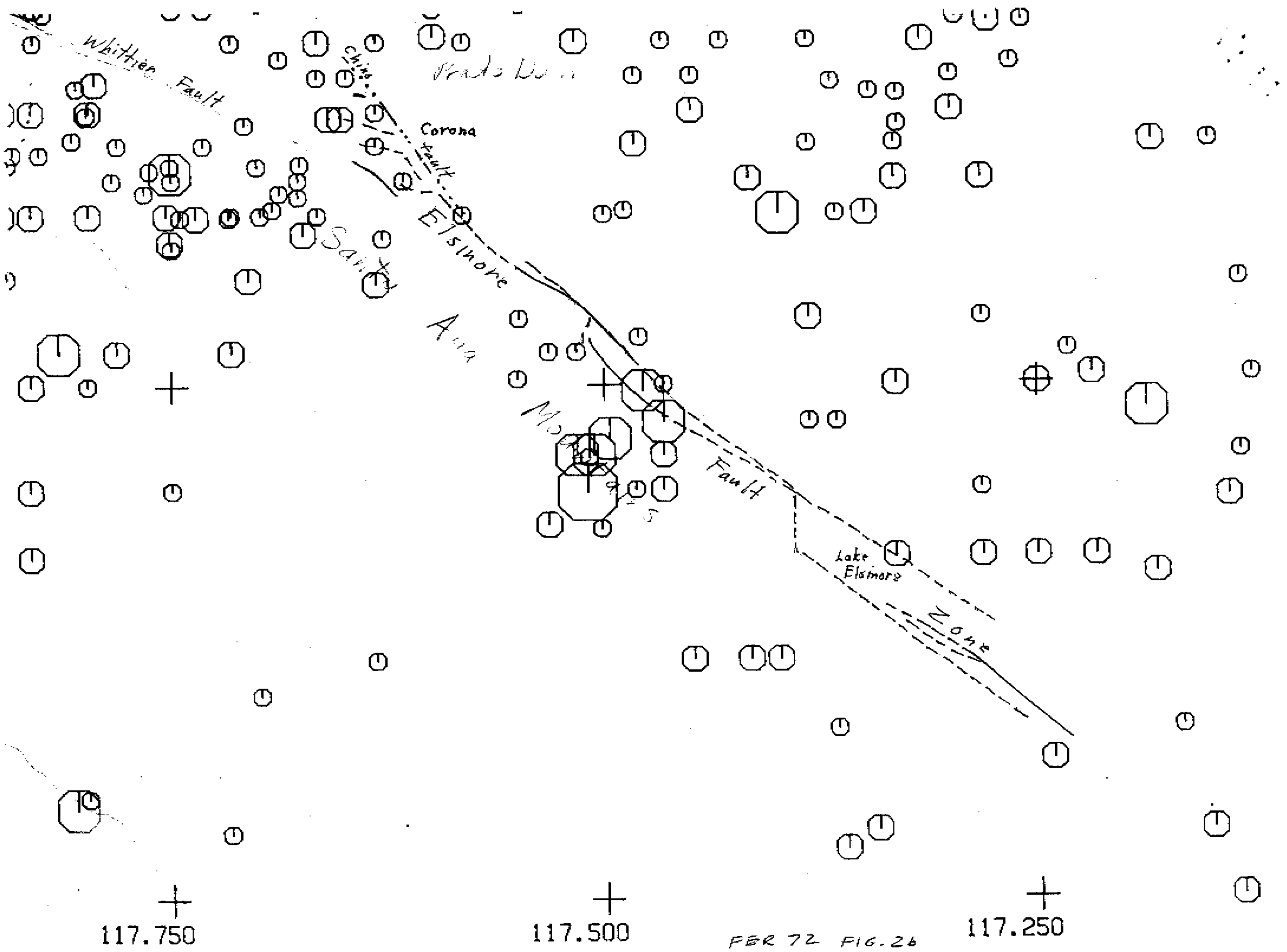
..... 4.0 TO 4.9

..... 5.0 TO 5.9

..... 6.0 TO 6.9

FER 72

Figure 2b. Seismicity in the vicinity of the Elsinore fault zone, 1900-1974, northern Riverside County. "B" quality epicenter plots from Real and others (1977) are of ± 5 km accuracy.



Whittier Fault
Chino
Prado Dam
Corona
fault
Elsinore
Santa Ana Mountains
Fault
Lake Elsinore
Zone
117.750
117.500
117.250

FER 72 FIG. 26

FER 72
Figure 3. A reproduction of figure 3 of Weber (1977, p. 25).

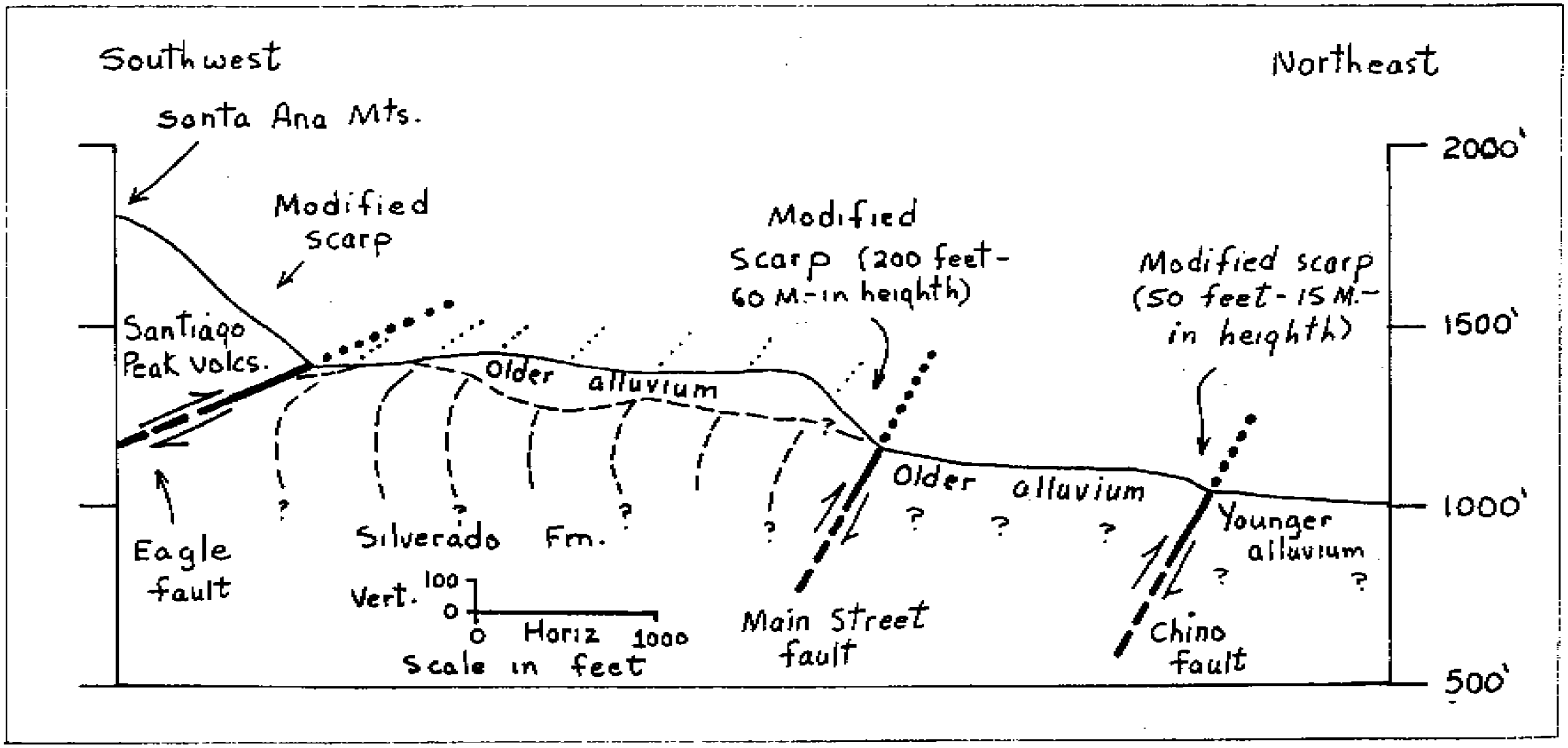


Figure 3. Cross section showing topographic aspects of fault scarps across Eagle and Main Street segments of Elsinore fault zone and Chino fault in area immediately southeast of Tin Mine and Hagador Canyons, southwest of Corona in foothills of Santa Ana Mountains. Vertical displacement of 200 feet (60m) on Main Street fault implies relative vertical uplift along fault at this point of about 1 foot each 750-1,500 years (based on an age of about 150,000 to 300,000 years for the older alluvium).

Appendix A

Table 1

Age of Youngest Rocks Displaced Along Faults

MAP SEGMENT A

(Plate 2A)

Age Symbol and Locality Number*	Fault and Location	Youngest Rocks Faulted, and Other Evidence for Recency of Faulting
LQ-1	Chino; northwest corner of map area	Well-developed, reddish-brown duricrust paleosol of late Quaternary age is apparently displaced vertically upward relatively perhaps 150 feet (50 m) or more on southwest side of fault.
LQ-2	Chino; northwest corner of map area	Older alluvium (Qov) is displaced perhaps as much as 50 to 100 feet (15 - 30 m) or more. Deflected drainages also suggest youthfulness of movement.
VQ(?)-3	Chino; northwest corner of map area	Fault traces in slightly older alluvium visible on pre-dam, 1939 aerial photographs.
LQ(?)-4	Chino; southeast of Prado Dam	Possible vague expression of faulting in older alluvium.
LQ-5	Chino; railroad cut, southeast of dam	Older alluvium is displaced upward to west at least 8 - 10 feet (2 - 3 m).
LQ-6	Chino(?); gulch, southwest of Wardlow Wash	Pre-older alluvium, flat-lying Quaternary sand and gravel is displaced downward on east side of fault.
LQ-7	Chino; between Paseo Grande and Avenida de Vista	Northeast-facing scarp 10 - 15 feet (3 - 5 m), in older alluvium, has been altered by erosion.
LQ-8	Chino; gulch east of Border Avenue	Subtle features exposed in cut in older alluvium suggest possible youthful faulting (see Figure 4).

LQ-9	Chino; 600 feet (200 m) southeast of Border Avenue	Recent observations, as well as older aerial photographs show citrus trees stunted in growth along trace of fault, suggesting near surface ground water effects and hence, possible faulting, near ground surface in older alluvium.
H(?)-10	Chino; Manguilar Avenue and vicinity	Vegetation along trace of fault in younger alluvium (Qsc) suggests very youthful faulting.
LQ-11	Chino; southeast of Border Avenue	Slight shear in cut at point approximately along trace of fault may reflect relative youthfulness of fault movement.
VQ(?)-12	Chino; Chase Drive	Youthful appearing scarp; relatively young fan deposits may be displaced.
LQ-13a	Main Street segment; southeast of Mabey Canyon	Red duricrust paleosol displaced upward and removed by erosion, southside of fault.
H(?)-13b	Main Street segment; west end of Upper Drive	Fault trace apparently cuts youthful alluvial sediments.
LQ(?)-14	Chino; Upper Drive	Fault may cut surface of older fan deposits.
PQ-15a	Scully Hill(?); Santa River area, western part of map	No direct evidence for Quaternary displacement.
PQ-15b	Unnamed; Santa Ana River, western part of map	Possible fault based on difference in attitudes of bedrock, opposite sides of canyon. No evidence of activity.
LQ(?)-16	Scully Hill and unnamed; Fresno Canyon area	Suggestion of possible if minor faulting of older alluvium (Qov).
PQ-17	Unnamed; east of Fresno Canyon	Prominent faults in Upper Cretaceous and Tertiary rocks apparently do not displace Quaternary rocks, but anomalous topography in Fresno Canyon suggests some relatively recent activity.
PQ-18	Unnamed; east of Fresno Canyon	Very short fault segment; anomalous outcrop of granitic rocks 15 to 25 feet square is in reverse fault contact with Upper Cretaceous conglomerate. Probably a short segment of a very old fault.

LQ(?)-19	Unnamed; west of mouth of Mabey Canyon	Older alluvium possibly is faulted.
LQ-20	Fresno segment and branches; west edge of map area	Landslide breccia of probable Late Quaternary age is displaced; also geomorphic features suggest youthfulness of faulting.
LQ-21	Fresno segment and branches; west edge of map area	Landslide breccia of probable Late Quaternary age is displaced.
LQ-22	Tin Mine segment; Wardlow Canyon	Older alluvium is displaced downward on north side of fault; also geomorphic evidence suggests youthfulness of faulting.
PQ-23	Eagle segment; Mabey and Tin Mine Canyons	No evidence of youthful faulting.
LQ-24	Two unnamed faults; east of Tin Mine Canyon	Older alluvium (Qof) is displaced downward to southeast along low scarp, on more southerly fault.
PQ-25	Eagle segment; between Hagador and Main Street Canyons.	No evidence of Quaternary faulting.
LQ-26	Main Street segment and other faults;between Main Street and Eagle Canyon	Faults displace older alluvium (Qof); also, youthful geomorphic aspects of faulting.
PQ-27	Eagle segment; between Eagle and Joseph Canyons	No evidence of Quaternary faulting.
VQ(?)-28	Main Street segment; Gilbert Avenue	Slightly older alluvium probably is displaced downward on northeast along steep, youthful scarp.
LQ-29	Eagle segment; east of Joseph Canyon	Faults indicated apparently displace landslide breccia.
LQ-30	Faults which branch from Eagle segment; northwest of Bedford Canyon	Faults indicated displace older alluvium; some displacement is along relatively youthful appearing scarps.

VQ(?)-31	Eagle segment; northwest of Bedford Canyon	Base of landslide appears to be faulted.
LQ-32	Unnamed; northwest of Bedford Canyon	Disordered mudflow breccia deposits are faulted.
H(?)-33	Unnamed; Bedford Canyon area	Aerial photos suggest vegetational growth along fault trace in younger alluvium, implying possible youthful activity.
LQ-34 (partly queried)	Eagle segment and branches; southeast of Bedford Canyon	Older alluvium displaced; deflected and beheaded drainages suggest recent faulting.
LQ-35	Eagle segment and branches; McBride Canyon	Older alluvium displaced; at most southeasterly locality vertical displacement greater than 25 feet (8 m).
LQ-36	Unnamed faults; Bedford Canyon	Possible displacement of older alluvium.
LQ-37	Unnamed faults; southeast of Bedford Canyon	Older alluvium is displaced.
LQ(?)-38	Unnamed; northeast of Prado Flood Control Basin	Possible displacement of older alluvium and topographic linearity suggest youthfulness of faulting (see text).
LQ(?)-39	Unnamed faults; northeast edge of area, east of Main Street	Possible faulting of older alluvium and internal drainage suggest relatively young faulting.
LQ(?)-40	Unnamed faults; northeast edge of area, east of Main Street	Possible faulting of older alluvium and internal drainage suggest relatively young faulting.
PQ-41	Unnamed faults; east of east end of Temescal Road, Corona	Youngest rocks faulted are pre-Quaternary, but geomorphic aspects of faulting suggest relative recency of faulting.
LQ-42	Unnamed; Ontario Avenue, slightly east of Highway 71 freeway overpass, Corona	Low roadcut shows thin older alluvium faulted.

MAP SEGMENT B
(Plate 2B)

H-43	Glen Ivy North segment and unnamed fault; Brown Canyon drainage	Vegetational lineament suggests faulting of younger alluvium. Right deflected drainage along Glen Ivy North fault suggests relatively recent activity.
LQ-44 (partly queried)	Glen Ivy South segment and unnamed faults; northwest end of Temescal Valley	Older alluvium (Qof) faulted; relatively recent activity suggested.
VQ-45	Glen Ivy South segment and other faults; northwestern Temescal Valley area	Slightly older alluvium (Qlf) apparently is displaced.
H-46	Glen Ivy North segment; northwest part of Temescal Valley	Because of vegetational growth along trace in alluvium (Qsc), relatively recent sediments may be faulted.
H-47 (partly queried)	Glen Ivy North and Glen Ivy South segments; northwestern Temescal Valley	GIN - Low, very youthful-appearing scarp, with small sag ponds along it, may displace younger alluvium (Qv); cracks visible during study in pavement of Lawson Road where it crosses fault probably are caused by settling of fill; GIS - Possible faulting of alluvial fan (Qf) and stream channel (Qsc) deposits suggested by mapping.
LQ-48	Glen Ivy South segment; southwest side of Temescal Valley.	Older alluvium displaced downward on northeast.
H-49 (partly queried)	Unnamed; Temescal Valley	Aerial photograph features suggest youthful faulting; relatively pristine scarp along most southwesterly portion of trace indicated.
LQ-50	Unnamed; Temescal Valley area	Mapping suggests that older alluvium may be faulted.
H(?)-51	Glen Ivy North and Glen Ivy South segments; southern Temescal Valley graben area	Faults appear to displace younger alluvium; depth of alluvium in graben is greater than 1,000 feet (330 m) and implies large vertical component of relatively recent faulting.

PQ-52	Unnamed; Santa Ana Mountains west of Temescal Valley	Contact between Jb and Kgr may be fault; no evidence to suggest Quaternary displacement.
VQ(?)-53	Unnamed; Temescal Valley area	Faulting within older alluvium may extend into younger sediments (Qfi-gr).
LQ-54 (partly queried)	Unnamed; Temescal Valley area	Older alluvium (Qov) is displaced.
H-55	Glen Ivy North and Glen Ivy South segments; Temescal Valley area	Similar to H(?)-51.
VQ(?)-56	Unnamed Temescal Valley area	Relatively prominent fault displaces older alluvium and perhaps slightly older alluvium.
PQ-57	Unnamed; Temescal Valley area	Possible older fault with no Quaternary displacement recognizable.
H-58	Unnamed; Indian Canyon drainage	Vegetational effect along trace of fault across Indian Canyon drainage (Qsc) suggests that relatively young sediments are faulted.
LQ-59	Unnamed faults; east of Indian Canyon drainage	Older alluvium (Qof-gr) may be displaced.
LQ-60	Unnamed faults; Horsethief Canyon drainage	Older alluvium faulted against Jb or Qob.
H-61	Glen Ivy North segment; Indian Canyon to Horsethief Canyon	Very young alluvial sediments (Qsc, Qv) are apparently faulted, as illustrated by strong vegetational and geomorphic effects.
H-62	Glen Ivy North segment; southeast of Horsethief Canyon drainage	Apparent, youthful scarp in younger alluvium faces northwest; scarp is slightly altered by man.
PQ-63	Walker Canyon lineament (fault?); southeast of Lee Lake to Walker Canyon	Possible northwest-trending fault trace apparently does not affect Quaternary sediments.

VQ-64	Unnamed ; northwest of Rice Canyon drainage	Probable faults along southwest side of small valley may branch from principal trace of Glen Ivy South fault or represent slightly older faulting along zone; faults probably displace slightly older alluvium (Qio).
H-65	Glen Ivy North segment Rice Canyon drainage	Vegetational effects across stream channel deposits (Qsc) indicate that relatively young sediments may be faulted.
VQ(?)-66	Unnamed ; Rice Canyon area	Ponded alluvium west of fault suggests relatively recent displacement.
LQ-67	Unnamed; McVicker Canyon	Older alluvium (Qof) is displaced.
H-68	Glen Ivy North segment and unnamed fault; southeast of Rice Canyon drainage	Strong, youthful scarp modified by erosion along Glen Ivy North fault faces southwest; scarp ranges in height from 0 - 25 feet (0 - 8 m).
Q-69	Unnamed ; southwest of Terra Cota	Strong linear fault displaces Pauba Formation(?) (Qup); probably a slightly older fault as it appears to be truncated by Glen Ivy North fault; some evidence, however, that faults northwest of old Highway 71 displace older alluvium (Qov).
PQ or LQ-70	Unnamed; north edge Warm Springs Valley	Possible fault borders north edge valley; may displace older alluvium; now probably inactive.
VQ-71	Unnamed; Leach Canyon drainage	Apparent faults extend along south side of Leach Canyon drainage. May displace older alluvium (Qia).
H-72	Willard segment; northwest end of Elsinore Valley	Youthful scarp-like features face northeast and suggest very youthful faulting in younger and slightly older valley fill (Qlv).

H-73(partly queried)	Wildomar segment; northwest end of Elsinore Valley	Wildomar fault may border southwest side of lake, and displace lake sediments; fault is extended arbitrarily northwestward as shown (Geomagnetic traverse by R. H. Chapman suggests that fault may extend at least to point slightly northwest of Machado Road as indicated).
H(?)-74	Glen Ivy North segment; northwest end of Elsinore Valley	Subtle geomorphic features suggest possible pattern of faulting shown and displacement of younger sediments.
PQ-75(partly queried)	Unnamed; southwest part of Warm Springs Valley	No evidence that strong but older faulting displaces Quaternary rocks.
H(?)-76	Elsinore North fault of Engel (1959); Warm Springs Valley	Line on map shows approximate site of fracture reported by Engel from accounts of others to have opened in 1918 by San Jacinto earthquake. No evidence of fracture could be discovered by writer.

MAP SEGMENT C
(Plate 2B)

H(?)-77	Willard segment; central part of Lake Elsinore basin	Youthful scarp-like features face east, in slightly older and younger alluvium (Qiv).
H(?)-78	Wildomar segment; central part of Lake Elsinore basin	Fault may extend northwest along southwest edge of lake and possibly displace relatively young lake sediments.
H(?)-79	Glen Ivy North segment; central and southeasterly portion of Elsinore Valley	Southwest-facing incline in bare lake bottom may be fault scarp, implying relatively young faulting of lake sediments.
H(?)-80	Willard segment; central and southeasterly portion of Elsinore Valley	Similar to H(?)-77.

H(?)-81	Wildomar segment; Lakeland Village area	Possible scarps in youthful lake sediments, and steep north slope of Rome Hill suggest relatively recent fault movement.
H(?)-82	Wildomar and Willard segments; Rome Hill and vicinity	Faults apparently displace younger and slightly older alluvium (Qiv).
H-83	Wildomar segment; southeast end of Elsinore Valley	Youthful scarps and other evidence suggest faulting is relatively recent.
LQ(?)-84	Glen Ivy North segment; Bundy Canyon Road and Orange Street intersection and vicinity	Mapping shows slight escarpment in older alluvium which suggests late Quaternary displacement.
VQ-85(partly queried)	Willard and Wildomar segments; Corydon Road and Grand Avenue intersection and vicinity	Similar to H(?)-82; topographic configuration of more southwesterly of Willard segment suggests moderate dip to southwest.
Q-86	Wildomar segment; southeast edge of map area	Apparent faults displace Pauba(?) Formation.
LQ-87	Wildomar segment; southeast edge of map area	Apparent trace of fault displaces older alluvium (Qov).
LQ(?)-88	Glen Ivy North segment; southeast edge of map area	Similar to LQ(?)-84.
VQ-89	Wildomar and Willard segments; southeast edge of map area	Similar to VQ-85; youthful-appearing scarp, closed depression imply relatively recent fault activity.

*Age symbols: H, Holocene (< 10,000 years); VQ, very late Quaternary (< 25,000-50,000 years); LQ, late Quaternary (< 500,000 years); Q, Quaternary (< 2-3 million years); PQ - Pre-Quaternary.